XIV.—*On the Development of the* Lycopodiaceæ. By Karl Müller*.

[With five Plates.]

[Continued from p. 40.]

§ 5. *The perfect Plant.*

We have here to consider:—1. the *axis of the branch*; 2. the *roots of the branch*; 3. the *leaves*; and 4. the *organs of reproduction.*

1. *The axis of the branch.* The germinating plant divides, as we have already seen, normally into two branches, consequently it is bifurcated. The same kind of division is exhibited throughout the whole growth of *Lycopodium denticulatum.* The branches are always dichotomous, the vascular bundle always dividing in this manner.

The branches, as is known, are compressed on the upper and under sides.

Interiorly they are composed of numerous layers of cells. At first two circular spots are found in the centre, lying at some distance from each other. In these situations are produced the vessels, which as usual are surrounded by long, prosenchymatous cells (Pl. III. fig. 12). They lie within the latter as a simple and almost circular group. From these vascular bundles proceed outward a number of tubular cells which finally come in contact with a layer of delicate and short parenchymatous cells. These last are the only cells throughout the whole axis of the branch which as yet contain any of the "cell-contents" (fig. 12 *a*), which consist of very small yellowish green granules, more or less collected into groups. The whole is inclosed by several layers of thin-walled, transparent and short parenchymatous cells. The layers situated most externally (the cortical layers) consist of cells which are always somewhat more elongated and more slender, and are not hexagonal, but have the form of parallelograms. Toward the terminal bud, the cells of the axis all become smaller and more crowded, till at last they look like mere globules (fig. 13).

All these conditions vary in the most manifold way in the stems of the other *Lycopodiaceæ.* This is especially the case with regard to the grouping of the vascular bundles. The structure of the cell-membrane also is very variable among them. These however are conditions of which a further examination would be extrinsic to my design. Most of them indeed are already known, and only individual cases require pointing out. The development

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of the cells of the terminal bud remains yet to be traced. I therefore next consider—

2. *The roots of the branch.* These are solid round bodies, almost perfectly cylindrical, which always split, like the axis, dichotomously when they come in contact with the ground, penetrate it, and attach the plant more firmly to it. When growing in pots however, as in our green-houses, and not long enough to reach the earth, they do not divide.

Interiorly they are made up of the same kind of cellular tissue as the axis of the branch; but the cells are firmer. They never contain more than one vascular bundle, and also differ from the axis in the fact that this bundle is not attached to the cortical layer by those tubular cells, whereby a large empty space is formed in the centre of the axis of the branch.

The most remarkable point about them is their extremely regular occurrence upon the axis of the branch. They *always* make their appearance in the situation where the axis splits into two, and in fact immediately in the axil of the last or penultimate leaf of the branch (Pl. II. fig. 17), which leaf is always a *folium intermedium*; the root consequently is always developed upon the upper side of the axis. Schleiden (in his Grundzüge, ed. 1. part ii. 80) expressly says of the roots, that they proceed from the under side. He has not mentioned the species in which he observed this, and therefore I am still in doubt as to the truth of the statement.

The rootlet appears at first as a little papilla upon the axis of the branch. This soon developes into a conical projection, and as soon as it has attained a certain length, which is not very considerable, the little cone curves downwards. This structure begins to be developed almost in the earliest stage of the growth of the axis of the branch, and the rootlet itself is found in that situation where the organs of reproduction are produced; a condition to which I shall have again to refer hereafter. Every joint of the branch consequently possesses a root at its base. A successful transverse section exhibits the history of development in the interior; at the particular point of the axis, where the root is to be formed, the tubular cells round the vascular bundle partly disappear; with the disappearance of these the vacant spaces also vanish, and the cortical parenchyma now immediately invests the central vascular bundle. On the upper side of the axis alone, consequently directly at the spot where the rootlet subsequently becomes visible, some tubular cells still occur, which however are of small importance compared with the former of the axis of the branch (Pl. IV. fig. 1). Indeed they are really only parenchymatous cells elongated upwards. Since these cells are wanting and the parenchyma is thus brought close to the vascular bundle, the nutrient fluids must naturally become concentrated at this point. This is in fact the case. In that situation where the root is to be formed, the cells soon become filled with a matter which distends them and is reddish like the often-mentioned material for development (*cytoblastema*). The root now begins to shoot outward, and may indeed be caused to project out by a simple mechanical process, by the expansion of its cells. The elongation continues to increase, the apex of the rootlet always remains filled with cytoblastema, and the older portions finally exhibit perfect cells, among which a delicate vascular bundle then soon penetrates, being a branch from the larger one of the axis of the branch (Pl. IV. fig. 2).

3. *The leaves.* As to their form and position, these conditions have already been examined in the germinating plant, to which I have only to add, that the perfect leaf of the axis of the branch is produced downward at its posterior face into a kind of tail, is enlarged into a roundish projection, and has the base so detached from the axis of the branch, that this apparent appendix looks like that appendage which we at first found on the basis of the envelopes of the bud (Pl. III. figs. 11 *d*, 11 *x*). However they cannot be confounded, since that is always a much more delicate, simple membrane, while here the green cellular tissue of the leaf usually extends to the apex of the appendage. It is only necessary, then, to speak of the relations of the leaf to the axis of the branch.

When a leaf is about to be developed upon this, a little elevation may be perceived upon its terminal bud. This prominence consists of an evident extension of the parts at the circumference of the axis of the branch, *i. e.* the young leaf at its first appearance is a flattened shoot, which has only to become extended in length and breadth to form a perfect leaf. In the interior of this shoot the material for development (*cytoblastema*) shows itself, and as the lamina extends itself, the cytoblastema is gradually converted into cells. At the same time, and equally keeping pace, a branch of the central vascular bundle—which always reaches almost to the point of the terminal bud and also keeps pace with its elongation—proceeds across through the delicate parenchyma in the interior of the leaf (Pl. III. fig. 11), where it terminates abruptly or in a clavate form, as in Ferns. At the same time, the long parenchymatous cells clothing the vessel naturally accompany it into the leaf, and around these assemble also the tubular cells. And thus the tissue of the leaf appears spongiform in the cross-section.

It must here be noticed, that both in the young branches and in the terminal bud, the surface of the axis of the branch is formed of a single layer of elongated cells (fig. 13), while at a later period several layers of similarly elongated cells clothe it (fig. 11 *b*).

The surface of the young leaf of *L. denticulatum* therefore consists of but one single layer of cells, which developes into the proper epidermis, subsequently contains *porous orifices,* and always remains as a membrane composed of a single layer. Its cells are always hyaline and of flattened form. Next to it interiorly follows a layer of larger, round cells, next the spongiform tissue, and lastly, the vascular bundle with its appurtenances.

The larger, round cells originally possess a nucleus which is firmly attached to the interior of the cell-wall: it is green and somewhat compressed. In this form it resembles a cytoblast, persisting in the cell, and I consider it as one, and that it has been converted into chlorophylle. Subsequently it separates into several granules, but not into many (fig. 11 *c*).

The leaves are consequently only prolongations of the parenchyma of the axis of the branch-axis, and never attain an independent position, as they universally remain attached by the whole base.

The relations of the leaves to each other is such, that the older, the inner face of which have by this time become concave, overlie the younger, and so on until we arrive at the delicate terminal bud which is completely inclosed by them, and, like the young, delicate and almost transparent leaves, is thus protected.

4. *The organs of reproduction.* I now come to a point which is undoubtedly the most important of all, since it exercises the most direct influence over the systematic position of the *Lycopodiaceæ.* This is the morphological import of the organs of reproduction. Having been long known, this question has not passed unnoticed. The first who expressed an opinion on the subject was Bischoff in his 'Lehr. d. Bot.' 1 Th. 421. He says, "The position of these fruit (this refers both to the oophoridia and antheridia) in the axil of the leaf appears to indicate that they are buds, the leaves of which, united in the younger stages to form the envelope of the fruit, separate when it is mature; they do not possess however the epidermal layer on the upper face. In favour of this view may be instanced the two- or three-chambered fruit of the foreign genus *Psilotum,* in which, at its first appearance, the corresponding number of leaves may be perceived, and which generally resembles in structure a chambered capsular fruit."

On the other hand, H. Mohl in his memoir above-cited (Morph. Betr. über das Sporang., &c.), p. 29, opposes this, and for two reasons: "In the first place," he says, "it appears that the sporangium is not actually situated in the axil of the leaf. This is shown indeed, although not very distinctly, by a careful examination of *Lycopodium*, in which it may be observed that the base of the sporangium is connected equally with the mid-nerve of the leaf, in the axil of which it is situated, and with the stem, so that its true point of insertion remains doubtful; this condition however is better marked in *Psilotum*, especially in *Tmesipteris*, as here the capsule is attached in the incisure of the leaf." The author then comes to speak of *Isoëtes*, where also two kinds of spores occur, by which the affinity to *Lycopodiaceæ* is so distinctly shown, and says that in *Isoëtes* the sporangia are decidedly not axillary but proceed from the leaf, whereby it is rendered probable that this is also the case in the *Lycopodiaceæ*, and that the sporangia are productions from the leaves. He further says, p. 30, "The position of the sporangium on the leaf of *Psilotum* might indeed be explained by an adhesion of the fruit-stalk to the leaf, but on the other hand there is the opposing circumstance, that in this family generally the fruit-stalk is remarkably short, and in *Isoëtes* no trace of it is to be found."

A second evidence against Bischoff's view is found by this author (Mohl) in the development of the spores contained in the fruit of the *Lycopodiaceæ*, "since this takes place in the same manner as in Ferns and the pollen-granules of the Phanerogamia, in mother-cells which fill the cavity of the fruit, and therefore indicates that it occurs in the interior of a cellular organ even as it does on the surface of a foliaceous part."—"This circumstance," he says further, p. 31, "appears to have led Bischoff to the assumption that the epidermis is wanting on the upper side of the carpellary leaf. The assumption, that in the single carpellary leaves, the face, folded inward, disappears either at first or during the course of development, and that the cavity of the carpel becomes filled with mother-cells which originate from the naked mesophyllum there present, is not indeed impossible in itself, but it is too little supported by any analogy to allow of our accepting it as valid without further examination of the point, in the present case where the position of the fruit generally renders its derivation from the leaf doubtful."

By these statements, Mohl endeavours to controvert Bischoff's view, and to render the other probable, that the sporangia of *Lycopodiaceæ* are productions from the leaves; for he says, himself, finally (p. 33), "the fact of the sporangium of *Psilotum* being two- and three-chambered, cannot, as it appears to me, be brought as an objection to the view thus proposed; for this structure may be explained as well by the growing together of two or three sporangia, formed like the thecæ of an anther, as by the union of carpels, and this the more that we find an analogous fusion of sporangia among the Ferns in *Danæa* and *Marattia*."

The third investigator, whose opinions on this subject I have become acquainted with, is Schleiden. He declares himself most decidedly in favour of Mohl's view, and says (Grundzüge, ed. 1. part ii. 81), "that the spore-fruits are special modifications of the parenchyma of the leaf, has been shown by Mohl as clearly as was possible without tracing the development. This however affords the same results." From this last sentence we may guess that Schleiden had founded his very definite statement on an examination of the development. This however is not to be found in his earlier writings, and it is therefore very much to be regretted that this author has not given us a more detailed account of it!

How far my own investigations agree with the foregoing opinions, will best be seen after I have given the history of the development so far as I have arrived at any conclusions about it; these I hope however may solve the questions above stated.

1. *The spike* (spica nonnullor., amenta et strobilus. *Spring.*).

The inflorescence of *Lycopodia* is always to be regarded as a spike: the peduncles of the fruit may be abbreviated and the leaves be thus brought closer together, in which case the character of the spike appears most distinctly, or the leaves may remain in their original position. In this latter case the fruit is said to be scattered on the stem. It will be evident that I here of course only speak of the genera *Lycopodium, Selaginella* and *Phylloglossum.*

The form of the spike naturally depends upon the arrangement of the leaves of the species, and therefore has usually no remarkable differences from the preceding whorls of leaves. In *Selaginella* alone it is regularly altered in such a manner, that while the leaves of the compressed branches, in four rows,—two above and two below,—are distant and of two forms, the leaves of the spike are densely crowded and thus form a four-sided spike on the round axis; for the little uniform leaflets are strongly keeled, overlap one another regularly, and the keel is thus displayed at a prominent line on the spike (Pl. IV. fig. 13). Four such lines occur normally, and the four-sided form is thus produced as the fruit-leaves are compressed so as to form an angle. The spike of *Lycopodium denticulatum* is of this form. Two circumstances have an important influence over its perfect development. If the axis of the branch does not become attached to the earth by its roots—and this is often the case in plants raised in pots—the spikelet of the branch which has not attached itself by rooting is manifestly retarded in its development, and often to such an extent that it scarcely visibly projects beyond the leaves; but on the other hand, when the branches always root, the spikelet acquires a considerable height.

On this now occur oophoridia and antheridia. The character of their occurrence varies in three ways. Either only antheridia appear on the spikelets (*L. Selago, clavatum, annotinum, inundatum,* the genus *Phylloglossum,* &c.), or only oophoridia (*L. selaginoides*), or both organs together. Here belongs *L. denticulatum,* apparently together with the whole genus *Selaginella* and some annual species of the genus *Lycopodium,* which represent, as it were, the pigmies of the *Lycopodiaceæ,* e. g. *L. gracillimum* and *pygmæum.* In these two the oophoridia are situated under the antheridia at different points on the spike. On the other hand, in *L. denticulatum* and other *Selaginellæ* in which I have become acquainted with the formation of the fruit, only one single oophoridium occurs on the spikelet, and that *always at its base.* This becomes of very great importance when we seek to discover the import of the oophoridium, and will be spoken of hereafter. In development however it is the simplest case, and therefore the most instructive.

Examining the base of the spikelet of *L. denticulatum* more closely, the oophoridium is found to rest upon two leaves, two *folia intermedia.* The spikelet, which beyond this point bears only antheridia, also has intermediate leaves from its very base, that is, on the side opposite the oophoridium, and the whole spikelet is furnished with them.

To trace the structure of the fruit-bearing portion of the axis, we must go back to the earliest condition of the terminal bud. The dichotomous division is always strongly marked in this bud, since the apex of the axis is always broader and more thickly clothed with leaves than the inferior portion. Inquiring into which portion is developed into the fruit-stalk, a very careful examination shows that it is *always that lying to the right hand.* That there may be no doubt as to left and right, the plant must be looked on from above. The upper side however is always that on which the *folia intermedia* are attached. When the axis has divided into two branches, that part lying to the left of the axis elongates and always divides in a similar manner further on, whence it generally happens, that the direction of the right-hand branch of the left axis is always diverted a few degrees towards the left as in all cases of bifurcation, and thus the plant is in a condition to spread to such an extent that it covers large circular areas.

So much for the fruit-bearing axis. I have now to explain more specially the development of the oophoridium and the antheridia, in order to make out their morphological import.

2. *The oophoridium.—a. The formation of the sporangium.* I do not dwell long upon the description of this, since its structure is nearly or almost wholly similar in most species, and may also be regarded as sufficiently understood. It is, briefly, a sporan-

gium of about the same size as the antheridia, the periphery presenting four rounded projections. These projecting portions are always opposed in pairs, so that their lines of intersection cross (Pl. IV. figs. 3—5). Schleiden (Grundz. ed. 1. ii. 82) calls it a rounded tetrahedral fruit; but the expression "*four-knobbed* (vierhügelige) *fruit*" appears to me much more indicative of its character, as a rounded tetrahedral form does not include the rounded projections which so distinctly occur. At its base the oophoridium is furnished with a short pedicel, compressed on two sides, which consequently resembles the axis of the branch (fig. 3). Around this pedicel is a circular spot consisting of delicate, minute and hyaline cellular tissue (fig. 4). From this runs out on each side a long, elliptical space which also consists of the same delicate tissue (fig. 4). The latter spaces indicate the line in which the oophoridium subsequently opens, without being itself actually torn. In *L. gracillimum* these two long spaces are dichotomously divided. The line of dehiscence also extends over the crown of the sporangium (fig. 5). The crown however is usually regularly depressed inward in the younger stages. The membrane of the oophoridium is composed of a layer of dense parenchymatous cellular tissue. On the inner wall of this is usually found an irregularly deposited, green cellular mass, which is apparently a secondary deposit: this is what we find in *L. denticulatum*. The four germinative spores found in the sporangium have already been spoken of in § 2; they form the four projections of the oophoridium.

When the fruit-bearing axis is examined in a very early condition—and this is necessary, since the organs of fructification are very rapidly developed—a relation between the oophoridium and antheridium shows itself, which cannot easily be detected in the subsequent fully-developed condition. The spikelets bearing the oophoridium and the antheridia here appear as perfectly distinct parts (fig. 6): they deviate from each other dichotomously, just as the young forking branches of the axis do. The oophoridium is at this time externally an almost angular, roundish, inflated body, the breadth not exceeding the length (fig. 6 *a*); but very soon, after it has produced the four spores in its interior, it acquires the already-noticed four-lobed form with much more distinctness. The oophoridium is then, generally, of a longish shape and compressed on two sides (fig. 10). In this ellipsoidal form it stands with the longer face on the base of the spike, so that the angle of the spike, produced by the above-described keel of the leaf, corresponds approximatively to the middle of the oophoridium (13 *a*). If this organ is now looked at laterally, so that the two prominences *a b* in fig. 10 lie on a level with the eye of the observer who thus looks along the long vertex of the ellipsoid, this vertex appears somewhat depressed inward as if emarginate (fig. 12 *a a*). If it is then looked at again on the side which brings the long face (*c d* in fig. 10) across the eye, the long side appears as a rounded trigone (fig. 11 *a b* is the other side lying behind). In all these forms the oophoridium can externally only be made out to be a vesicular projecting organ, and naturally so, since the four spores have not yet become developed into compact masses. In proportion as the spores are perfected it appears to become gradually denser until it acquires the above-described four-lobed shape.

Here, before we know anything of the interior of the oophoridium, the question proposes itself, *What is the oophoridium actually?* According to all that I have hitherto said about it, the oophoridium is *the whole, metamorphosed terminal bud of a main axis. It is therefore an axial organ.*

Most important grounds support this opinion. The first is the independent position of the oophoridium, opposite the spike, in the early condition (fig. 6 *a*). Here we distinctly see *the oophoridium and spikelet are the two metamorphosed branches into which a main branch has just divided.* In a later condition it does certainly appear as if both oophoridium and spikelet belonged to one single axis. There can however be so little doubt about our having to do with two branches, that in the absence of other argument, this mode of development alone would be sufficient to warrant my opinion. All that a branch possesses is found with the oophoridium, since we have already seen above that it is protected by two leaves; and these two intermediate leaves are to be regarded as the two first of that which is here developed into an oophoridium. We also saw above, that near the oophoridium and the spike is often produced the same root which appears in the bifurcation of a main axis. Moreover that in *L. denticulatum,* as in most of the *Selaginellæ,* only one oophoridium is found on each fruit-bearing axis, speaks equally in favour of my view, since it stands in exact connexion with the scattered fructification of the said axis. The branches divide too frequently in *L. denticulatum* for the branch to produce many fruits. It is too thin to form a main axis out of which oophoridia might be developed. The case is different in *L. selaginoides.* Here the axis of the fruit is very thick, and thus it is suited to form *branches* which may develope into oophoridia. Another proof is, that in the young condition the oophoridia are all compressed, as the branch of *L. denticulatum* always is, since the oophoridium is in fact only the transformed apex of the branch. The internal course of the vascular bundle is even a better evidence, for a vascular bundle runs into the pedicel of the oophoridium (fig. 14), a condition which must be further examined hereafter. Finally, the view becomes incontrovertible from an anomaly which I have observed once, *where both the branches of the fruit-bearing axis had been transformed into oophoridia.* Here of course the spikelet was wanting, and two oophoridia were opposed to each other, the most complete proof that the terminal bud of *that* branch had been transformed into an oophoridium, which properly should have produced a branch.

It would be very interesting to trace the formation of the oophoridia in a fruit-axis which bears these organs alone, as in *L. selaginoides.* Here the axis of the branch is very slender, as in *L. denticulatum,* but the formation of the oophoridia, which takes place within a spike, is distinct. This is explained, as we have already seen, only by the thickness of the *fruit*-axis, as this increases in thickness as it proceeds upwards, and does not branch beyond like the inferior portion of the axis of the branch. This ramification however occurs again above in a more evident degree, since the individual joints of the axis become so distinctly shortened that the stalk of the spikes becomes diverted outwards. Here also there is no doubt that the oophoridium is a metamorphosed branch, and a history of the development of this most interesting species is very desirable.

Consequently the view of H. Mohl and Schleiden in reference to the oophoridium, that this sporangium is a production from the leaf, is certainly incorrect; neither is it formed of carpellary leaves, as Bischoff endeavoured to show.

b. The formation of spores. A new question to which I now come relates to the formation of the four germinative spores in the interior of the oophoridium. I regret that I cannot offer a perfect account of their development. What my researches have hitherto made me acquainted with on this point is limited to the following.

If we cut through the oophoridium in the direction of its length in a very young condition, the view of the interior confirms what we have above concluded from its external conformation. The membrane of the oophoridium is a mere development of the apex of the axis and is identical with the epidermis of the leaf, both being formed by the outermost cellular layer of the axis (figs. 7, 8). It is only at a subsequent period that the leaf acquires an organ, the porous slit, which never shows itself in the oophoridium. The membrane of the oophoridium is not equally strong at all points, but much thickened at the vertex (fig. 7 *a*). It is also decurved somewhat over its point of attachment, the future pedicel (fig. 7 *b*), whence this latter comes to be situated in a longitudinal fold which is continuous with the base.

Projecting into the interior of this cavity may now be discerned a more or less roundish vesicle (figs. 7 *c*, 9 *a*). This is formed of a very delicate, homogeneous membrane, perfectly hyaline, therefore devoid of contents, and surrounded at its base by a great number of smaller, more or less hyaline cells. This vesicle is now apparently only the apex of the proper central axis of the vascular bundle, as may be seen in figs. 7 and 9; and those cells occurring at the base of the vesicle are the terminal ones of the axis of the branch, the growth of which has not nearly kept pace with that of the external cortical layer of the branch-axis, and thus the cortical layer has become isolated and appears as the sporangium. These cells subsequently acquire some green contents; but they undergo no further development, and exist in the perfect oophoridium merely as a compact mass of cells out of which project the four spores.

The four spores however are formed in the vesicle produced from the apex of the vascular bundle, and I have hitherto only met with them in one single stage (fig. 15). Here they all four lay closely grouped together and occupied the greater part of the cavity of the vesicle. Each spore was already composed of a very delicate, somewhat reddish-coloured membrane, *which however though still so young was already cellular*. This last circumstance has as yet remained perfectly incomprehensible to me.

Should subsequent investigations show that this cellular structure is only apparent, and that this appearance coincides with the ridge-like projections which so often occur on the pollen-grains of the Phanerogamia, the question of the origin of the four germinative spores would be very clearly solved. We should here have in the interior of the oophoridium exactly the same law, that the matter contained in a mother-cell in the pollen-grain is formed, regularly, into four portions—subsequently four pollen-grains. We should have, in this vesicle, an actual mother-cell.

The further development of the spore is nothing more than a gradual expansion of its membrane, *which soon acquires a yellow colour*. It is quite empty, the form flat and compressed, and tetrahedral in the same way as the antheridia-spores, so that a long ridge may be observed on it (fig. 16). Little elevations also soon show themselves upon it,—a sign that the membrane is becoming thickened by the deposition of membranous matter. As the spore increases in size however, the vesicle in which it was formed disappears, and the four spores, which were originally situated directly on the summit of the central axis, now lie scattered in the four projecting lobes of the spore (sporangium ?). They go on swelling and becoming more thickened, until they are at last found in that condition which was described in § 2.

The course of development of these spores must be very clearly exhibited in *L. selaginoides,* where it must be possible to find a great many stages at one time on a single spike, as so many oophoridia occur on it. They must be also very easy to prepare for examination here,—a matter of exceeding difficulty in *L. denticulatum.*

In conclusion to these remarks on the oophoridium, two words on the affinities of *Isoëtes* and *Lycopodium.* It appears to me that this question involves the import which must be attributed to the large spore-sporangia of *Isoëtes.* Are these metamorphosed branches or not? In the latter case the affinity would be merely apparent, only inasmuch that both, *Isoëtes* and *Lycopodium,* exhibit two kinds of spores. In the former case, however, the affinity would be perfectly proved. The compressed, concentrated stem of the *Isoëteæ* would not be any great evidence against the affinity, since we have become, through Kunze, acquainted with the genus *Phylloglossum.* This is apparently a connecting link between *Isoëtes* and *Lycopodium;* and if A. Braun's opinion be correct, that *Phylloglossum* is to be regarded as a *Lycopodium acaule, Isoëtes* would also have to be regarded as a *planta acaulis* of the *Lycopodiaceæ.* It is readily conceivable that the term stemless plant is not to be taken here in its strictest sense, but rather to be understood as indicating a plant with an abbreviated stem.

Lastly, in reference to the import of the germinative spore of the oophoridium, Bischoff (Krypt. Gew. 126) has called them spore-bulbels (*tubercula sporoidea*), and compared them to the bulbels of *Arum ternatum* and *Dentaria bulbifera.* It is evident that this has no meaning till we know the whole course of development. The same applies to the expression *receptaculum tuberculiferum,* which he applied to the oophoridium. I have preferred the latter name because it is the more simple.

[To be continued.]

XV.—*An Outline of an Arrangement of Stony Corals.* By J. E. Gray, F.R.S. &c.

About ten years ago, when I arranged the Corals in the British Museum, I was struck with the difficulty of determining with precision the proper situation in the system either of Lamarck or De Blainville, of a large number of the specimens we then possessed, and in the 'Synopsis' I made some remarks on the variation which accidental circumstances, such as localities, &c., appeared to have on specimens of the same species. Since that period I have examined the collections of corals which have come in my way, and selected for the Museum collection the